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ABSTRACT

As the first lesson of the Articulated Multimedia Physics Course, instructional materials are presented in this study guide with relation to measurement and unit systems. An introduction is given for the realm of mechanics. The subject content is provided in scrambled form, and the use of matrix transparencies is required for students to control their learning process. In addition, students are asked to use magnetic tape playback, instructional tapes, and single concept films at the appropriate place in conjunction with a worksheet. Included are a problem assignment sheet, a study guide slipsheet, illustrations for explanation purposes, and a table of unit conversion factors. Related documents are SE 015 963 through SE 015 977. (CC)

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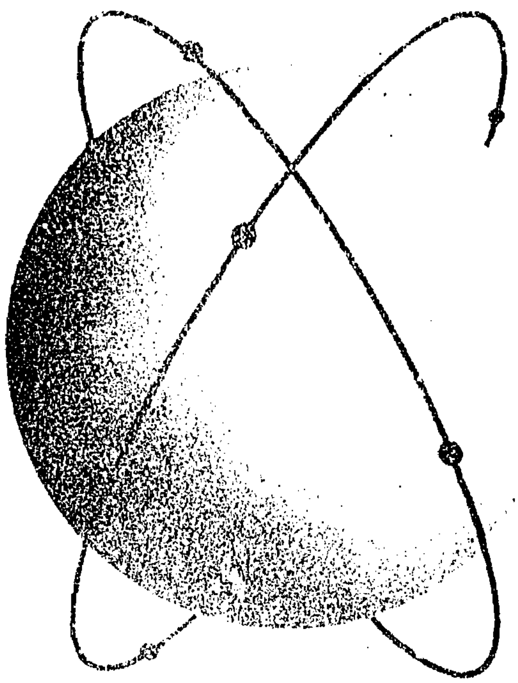
ARTICULATED MULTIMEDIA PHYSICS



LESSON 1

NEW YORK INSTITUTE OF TECHNOLOGY
OLD WESTBURY, NEW YORK

NEW YORK INSTITUTE OF TECHNOLOGY

Old Westbury, Long Island

New York, N.Y.

ARTICULATED MULTIMEDIA PHYSICS

Lesson Number 1

MEASUREMENT AND UNIT SYSTEMS

IMPORTANT INSTRUCTIONS

Before starting the course in Articulated Multimedia Physics, you are to listen to the first segment of the audio tape for Lesson 1. This segment appears at the very beginning of the cartridge and will serve as an introduction to the course. It carries certain information necessary to the procedures that will be used, so be sure to listen to it carefully before proceeding.

It will be necessary, of course, for you to receive the instructions you need to load the tape cartridge into the playback equipment -- so before you make any attempt to begin, be sure to request these instructions. We might note here that each tape segment terminates with a musical tone so that you know it is finished. In most cases you will be directed to a Worksheet for that segment in the back of this Study Guide (the section printed on BLUE PAPER). Then, when that section of the worksheet is finished, you are expected to return to the Study Guide to continue with the program. However, for the introductory tape segment you are to go to page 1 of this Study Guide when you have finished listening to it.

At this time, then, please take the steps necessary to load the cartridge for Lesson 1 into the playback and listen to the opening introductory segment. Thank you.

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New York Institute of Technology
Articulated Multimedia Physics
LESSON 1

STUDY GUIDE SLIPSHEET

To the Student: Each STUDY GUIDE is accompanied by a slip sheet like this under the front cover. It contains instructions for changes that you are to make in the text material, the homework problems, or in the diagrams unless these changes have already been entered by the student who may have used the STUDY GUIDE before you. In any case, you must ascertain that the changes have been made BEFORE you start to work. Your progress through the Lesson will be greatly facilitated by doing this as instructed.

STUDY GUIDE TEXT: No changes.

STUDY GUIDE DIAGRAMS: No changes.

WORKSHEETS: There are no changes to be made on the worksheets, but please take note of the following information: the first audio tape segment in this Lesson is not associated with a worksheet; it is merely an introduction to the course, to be listened to but not reacted to. The second segment of the audio tape is associated with Worksheet 1, thence in order throughout the Lesson.

HOMEWORK PROBLEMS: Turn to the homework problem sheet (the pink sheet at the very end of the STUDY GUIDE. Go to Problem 9. Enter in parentheses at the end of this problem the following: (The volume of a sphere is given by the formula

$$V = \frac{4}{3}\pi r^3 \text{)}$$

When the changes indicated above have been checked, you may begin the Lesson.

INTRODUCTION

Physics is a science with a long and glorious history. It is as old as ancient Babylon yet as new as this morning's newspaper. As far back as 1400 B. C. its principles were used in measuring time and predicting eclipses with amazing accuracy. Tomorrow you may read of some fantastic triumph in the physics of space travel or nuclear energy.

What is physics? It is, above all, a basic science of the natural world. But if we were to stop here this would also define biology, chemistry, geology, and other sciences as well as physics. We go further by recognizing that physics deals with things such as time, space, matter, and energy. In this way dividing lines are drawn between physics and other pure sciences such as chemistry and biology. In the modern world, however, these divisions have gradually blurred and all but vanished entirely.

There is the biophysicist whose knowledge of physics must be profound if he is to succeed in his vocation; there is the astrophysicist who may be an astronomer by choice but who requires a strong knowledge of physics to carry on his work; and there is the geophysicist who studies the earth itself, using physics as his most powerful tool. With each passing year the old lines of demarcation between the sciences become harder to define.

Please turn to the next page.

In preparing to teach or to learn a new subject it is natural to divide and classify the body of knowledge into logical groups. For this reason, we shall tentatively divide our course in physics into Mecahnics, Energy and Heat, Wave Phenomena, Sound, Light, Electricity, and Electromagnetism. But let us constantly bear in mind the fact that physics is <u>one science</u>, not a number of isolated and disconnected topics

Running through the fabric of physics are fundamental principles which are encountered again and again in each of our artificially divided phases.

We first hear of the principle of conservation of energy in studying Mechanics, but this basic idea pops up repeatedly in every other phase. We encounter an "inverse square law," when we study gravitation; then we find that the same type of law operates in the fields of light, electricity, and magnetism as well. We shall begin our study of physics with Mechanics, not because it is the most important or even the most interesting phase of the subject, but because it provides the foundation upon which all phases of physics rest.

Physics is normally presented as an 11th or 12th year high school science. This means that you have already had elementary courses in algebra and plane geometry as well as some basic training in the sciences. For this course, therefore, we shall assume that you have learned basic arithmetic and simple mathematics.

Please turn to the next page.

One more matter needs clarification before you embark on what we think will be a fascinating and profitable excursion into the realm of Mechanics; you will need a notebook. Any type will do, but we recommend the standard $8\frac{1}{2}$" x 11" spiral-bound notebook because it opens flat and stays that way. You will be required to keep precise notes throughout the program. In fact, you will find that a well-kept notebook will help you to proceed smoothly and confidently from one step to the next. Your notes will be checked periodically for accuracy. So, when the instructions tell you to take certain notes, make sure you copy the material exactly as it is presented.

You will also need a centimeter scale and a protractor for certain measurements. Plastic scales are available in most stationary stores at nominal cost.

The first lesson in entitled Measurement and Unit Systems. It deals with the uses of measurements, the method of making simple measurements as applied to physics, and the system of units preferred by physicists today.

Go to it! Best of luck!

Please turn to the next page.

Without measurements and systems of units most scientific experimentation would come to an abrupt halt. Certainly all commerce and world trade would be virtually impossible. If you were a wheat grower attempting to sell your product in the market for $1.50 "per package," the first question from your prospective customer would be, "How big is a package? How much does it weigh?"

Long before our modern measuring tools were invented, man made rough measurements using only his senses. With experience you can guess fairly closely the length of a log by "hand spans." You can sometimes tell which of two objects is heavier by "hefting" them in your hands. The passage of time may be determined approximately by your stomach's hunger growls between meals, or by counting heartbeats.

Your eyes are effective instruments for comparing lengths or distances only when the lengths differ considerably. For example, compare the lengths of line 1 and line 2 in the diagram below.

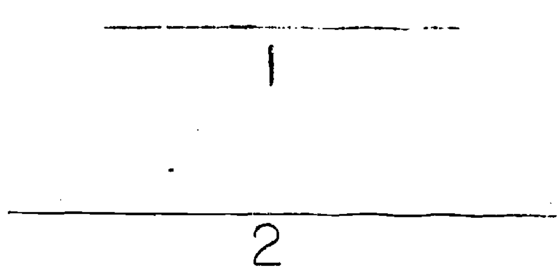

Figure 1

(1)

A If you think that line 2 is longer than line 1.

B If you think that line 1 is longer than line 2.

YOUR ANSWER --- A

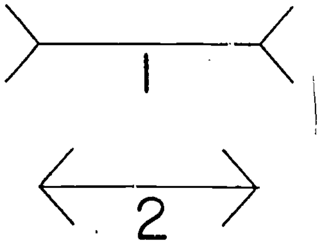

Figure 3

The optical illusion is so strong that you may have permitted the evidence obtained by visual inspection to influence your judgement in reading the scale.

Please return to page 16 and select another answer.

YOUR ANSWER --- C

Your decimal point slipped one place to the right. One-hundredth of a mile, expressed in feet, is 5,280 divided by 100, or:

$$\frac{5,280}{100} = 52.8$$

To obtain your answer you must have divided 528 by 3. You can see now why this is incorrect.

Please return to page 76 and select another answer.

YOUR ANSWER --- C

At least you had the right idea.

If the distance from the North Pole to the Equator along the prime meridian is roughly 30,000,000 feet and if a meter is one ten-millionth of this distance, then you must divide 30,000,000 by 10,000,000. To get your answer, you divided by 1,000,000 making your answer 10 times larger than it should be.

Please return to page 46 and select another answer.

YOUR ANSWER --- C

You are correct. Since a meter contains about 3 feet, a man who is 2 meters tall would be 6 feet tall. Six-footers, although not rare in our society, are still considered "good-sized."

The meter may be a good unit for measuring the length of your living room but it would be inconvenient for measuring the distance between New York and San Francisco. It is too small a unit for long distance measurements like this. On the other hand, the meter would hardly do as a unit for measuring the thickness of a dime or a sheet of paper. To extend the usefulness of the Metric System (so named because the basic unit is the meter), the French introduced various multiples and subdivisions of the basic meter.

We are about ready to start you on your notebook. On the first page, be sure to enter your name and the address to which the notebook should be returned if lost. On the next right-hand page, at the top line, write "Lesson 1, Measurement and Unit Systems." Then skip 2 lines. At the left margin, write the number 1. Alongside this number, write "Table of Metric Lengths and Useful Conversion Factors." Skip one line; then copy the following information:

1. Table of Metric Lengths and Useful Conversion Factors

1 kilometer (km) = 1,000 meters (m)	Conversions
1 meter (m) = standard of length	
1 decimeter (dm) = 0.1 meter	1 meter (m) = 39.37 inches
1 centimeter (cm) = 0.01 meter	1 inch (in) = 2.54 cm
1 millimeter (mm) = 0.001 meter	1 mile (mi) = 1.61 km

Please continue to the next page.

This table does not present the complete set of metric lengths but only those for which we will have use. You should study the list and memorize the relative sizes of the units, their abbreviations, and their relationships to the more familiar but less convenient English units. Notice how easy it is to convert any metric measure to another simply by moving the decimal point. This, of course, is the principal advantage of the Metric System. Study each of the following examples:

1,500 m = 1.5 km	There are 1,000 m in one km, (or, better, 1,000 m per km).
8 m = 800 cm	There are 100 cm per m (or, if you like, 0.01 m per cm).
32 cm = 320 mm	There are 10 mm per cm.
0.95 km = 950 m	There are 1,000 m per km (or 0.001 km per m).
18,000 mm = 18 m	There are 10 mm per cm and 100 cm per m; in other words, 1,000 mm per m (or 0.001 m per mm).
165 mm = 16.5 cm	There is 0.1 cm per mm.

For a quick check on your understanding of metric conversions answer the question: How many km are there in 265,000 cm?

(9)

A 2.65 km.

B 265 km.

YOUR ANSWER --- A

Now, let's see which of these units gave you trouble. Was it the light-year? This is a length unit very important to the astronomer. It is the distance traveled by light through a vacuum in one year. Since light travels about 186,000 miles in each second, you can figure out the number of miles it will travel in a year. A light-year is an enormous distance measured by everyday standards.

Perhaps you are not familiar with the rod. A rod is an old measure of length equal to about $16\frac{1}{2}$ feet.

How about the fathom? You must have heard this unit applied to measuring depths in the ocean. It, too, is a measure of length and is equal to 6 feet.

Thus, all of these units--light-year, foot, rod, and fathom--are indeed units of length or distance.

Please return to page 27 and select another answer.

YOUR ANSWER --- A

No. There is an error in the last problem.

6.8 m x 1,000 mm/m = 6,800 mm

This does not correspond with the answer given in the group above. There are 1,000 mm per m, so we must multiply 6.8 x 1,000 in order to obtain the number of millimeters contained in 6.8 m. The number 680 is only 100 times as large as 6.8. Careful with those decimals!

Please return to page 70 and select another answer.

YOUR ANSWER --- A

You were too ambitious!

Any factor in the numerator can cancel out only one identical factor in the denominator. You did this:

$$\frac{8}{\cancel{5}} \times \frac{4}{1} \times \frac{\cancel{5}}{4} \times \frac{\cancel{5}}{1}$$

You cancelled one "5" in the denominator by two "5's" in the numerator; the two 5's multiplied make 25. Only one of the two numerator "5's" can be taken out by the "5" in the denominator. With units also, be careful not to cancel more than one in the numerator with one in the denominator.

Please return to page 24 and select another answer.

YOUR ANSWER --- A

These units would cancel the units in the final term very well; but they would leave you with "km."

Actually, we want the "km" to cancel out, and we want to be left with the term "cm." One term mentioned will do it.

Please return to page 17 and select another answer.

YOUR ANSWER --- C

This answer is wrong. It might be the result of some carelessness along the way, but let's run through the explanation again using a numerical example. In the division $\frac{mm}{mm/m}$ you are asked to divide a whole number (mm) by a fraction (mm/m). As an example, suppose the whole number is 12 and the fractional divisor is 3/4 Hence, the operation to be performed is:

$$\frac{12}{3/4}$$

The rules of arithmetic tell us that 12 divided by 3/4 is the equivalent of 12 multiplied by 4/3. In general, any division may be changed to a multiplication by using the reciprocal of the divisor as the multiplier. Here are some examples:

$\frac{18}{2/3}$ may be written as 18 x 3/2 which equals 27.

$\frac{81}{9/5}$ may be written as 81 x 5/9 which equals 45.

$\frac{ab}{a/b}$ may be written as ab x b/a which equals b^2.

Apply this rule to the problem at hand.

Please return to page 47 and select another answer.

YOUR ANSWER --- A

You are correct. Dividing 6.640 by 1,000 and then by 100 is the same thing as dividing by 100,000. This calls for a shift of the decimal point 5 places to the left. Thus:

$$6{,}640 \text{ cm} = 0.0664 \text{ km}$$

Later on, when we study circular motion, we will have an equation with units distributed like this:

$$F = \frac{\text{kgm x (m/sec)}^2}{\text{m}}$$

What are the units for the term "F"?

(18)

A $\frac{\text{kgm x m}}{\text{sec}}$

B $\frac{\text{kgm x m}}{\text{sec}^2}$

C $\frac{\text{kgm}}{\text{sec}}$

D $\frac{\text{kgm}}{\text{sec}^2}$

YOUR ANSWER --- D

You are correct. The three lines are exactly equal in length, yet their relative positions give the appearance of inequality. Placing a scale, (or ruler as you might call it) alongside each in turn immediately discloses that the lengths are the same. In this simple example we see the need for a measuring instrument that cannot be fooled by positions or angles.

Get your scale handy and inspect the lines in Figure 3, first visually and then by means of the scale. What does your eye say about the respective lengths of the horizontal portions of line 1 and line 2?

Now use your scale on these two lines.

What information does your scale give you regarding the lengths of these two lines?

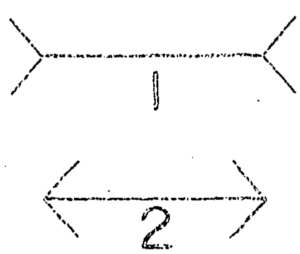

Figure 3

(3)

A Line 1 is longer than line 2.

B The lines are equal in length.

Completing the problem, we have:

$$4.7\ \cancel{km} \times 1{,}000\ m/\cancel{km} = 4{,}700\ m$$

Let's try another example: Convert 0.025 km to cm. Setting up the expression for the conversion, we write:

$$0.025\ km \times ??? \times 100\ cm/m =$$

What is the correct expression for the missing term?

(14)

A 1,000 m/cm

B 1,000 km/m

C 1,000 m/km

YOUR ANSWER --- B

This answer is incorrect in the second decimal place. Here is the division:

```
     3.28
  ______
12)39.37
   36
   ---
    3 3
    2 4
    ---
      97
      96
      --
       1
```

Please return to page 57 and select the correct answer.

YOUR ANSWER --- A

Sorry! You're still having trouble with the ratio idea.

The cart alone has a mass of m and weighs 2 lbs. If we add three additional masses, each equal to m, the new mass is now the sum of the mass of the cart and the added bodies. Thus, the new mass is $m + 3m = 4m$. The ratio of the new total mass (4m), to the old mass (m) is 4:1. Thus, the weight of the cart must increase in the ratio 4:1, as long as we accept the process of direct proportion between mass and weight. Your answer for the new weight was 6 lbs and the original weight was 2 lbs. These weights are not in a 4:1 ratio, are they?

Please return to page 98 and select another answer.

YOUR ANSWER --- B

You performed one operation correctly but missed on the second one. To find the number of feet in 1/100 of a mile, you divided 5,280 by 100 thus:

$$\frac{5,280}{100} = 52.8$$

This is correct. Since the yard is 3 times as large as the foot, any given distance will contain only 1/3 as many yards as feet. In your second operation you multiplied 52.8 by 3 instead of dividing by 3. Now you should be able to see why this is incorrect.

Please return to page 76 and select another answer.

YOUR ANSWER --- C

You determined the number of seconds in a day by multiplying 60 sec/min x 60 min/hr x 24 hr/day = 86,400 sec/day. But the question asks you to determine the number of seconds in an hour. You should be able to answer this immediately by eliminating the last step of the multiplication above.

Return to page 68 and select another answer.

YOUR ANSWER --- B

We didn't say that. Not quite. A definition is correct or incorrect depending upon whether it is unversally accepted by people who work with the quantity being defined. Actually, this definition is partially correct in that it provides a mental picture of the thing we call mass. The trouble is that the meaning of the word "quantity" is not clear.

Please return to page 22 and select another answer.

YOUR ANSWER --- B

If 1 kg weighs 2.2 lbs, how can 6.6 kg weigh only 3 lbs?

The easiest way to handle this is to say that there are 2.2 lbs of weight per kilogram, or more simply, 2.2 lbs/kg. Then we write out an expression which will give us an answer in lbs as the weight of 6.6 kg.

2.2 lbs/kg x 6.6 kg = ??? lbs

Please return to page 79 and select another answer.

YOUR ANSWER --- B

Are you sure?

Consider this simple example using fractions:

$$25 \times \frac{2}{25}$$

The 25 at the left is a numerator because the number 1 is assumed to be present in the denominator of any whole number. Thus, what we're really dealing with is this:

$$\frac{25}{1} \times \frac{2}{25}$$

The rules of arithmetic permit you to cancel in this way:

$$\cancel{25} \times \frac{2}{\cancel{25}} = 2$$

Use the cancellation method to find the correct answer to the problem below.

$$\frac{8}{5} \times \frac{4}{1} \times \frac{5}{4} \times \frac{5}{1} = ???$$

(13)

A 8

B 40

YOUR ANSWER --- A

This can't be right because the kilometer is a smaller unit of distance than the mile; hence to travel a given distance in miles you would cover a greater number of kilometers. (Check your notebook conversion figures.)

If you write it this way, you can't make a mistake:

$$60 \text{ mi/hr} \times 1.61 \text{ km/mi}$$

By cancelling the "mi" on one side by the "mi" on the other side, the unit of the answer will be "km/hr." This is exactly what we want. But, to obtain the answer you selected, you would have to divide 60 by 1.61. This gives the wrong number and also the wrong units.

$$\frac{60 \text{ mi/hr}}{1.61 \text{ km/mi}} = 60 \text{ mi/hr} \times 1/1.61 \text{ mi/km} =$$

$$37.3 \text{ mi}^2\text{/km-hr}$$

You must admit that the unit of this answer is incorrect, which shows that multiplication, not division, is called for.

Please return to page 90 and select another answer.

YOUR ANSWER --- A

You are correct. The definition is vague because the meaning of the word "quantity" is not clear. Unfortunately, a rigorous definition of mass depends upon concepts yet to be developed, so we'll have to be satisfied for the moment with the idea of mass as a quantity of matter. But we're lucky in one other respect: weight is a quantity that everyone knows about, and we can tell a great deal about the mass of a body if we know its weight. The weight of a given body in a given place is directly proportional to its mass.

Before continuing, please turn to page 113.

For example, suppose we weigh a tennis ball on a spring scale such as fishermen use. Say the ball weighs 3 ounces and assume, furthermore, that the mass of the ball is designated as m. Now imagine that some lead shot is poured into the ball until its weight just doubles, that is, becomes 6 ounces. Its mass would then be 2m, or twice as great as before.

Suppose that we pour in enough shot to give the ball a weight of 9 ounces (triple its original weight). The mass of the ball would then be 3m, or triple the original mass.

One characteristic of a direct proportion is that if one quantity is increased or decreased by any amount, the other quantity will increase or decrease in the same ratio.

Thus, for the tennis ball, what would its mass be if its weight were increased to 30 ounces by adding shot?

(27)

A 10 m.

B 30 m.

YOUR ANSWER --- A

You are correct. Of course, we don't know whether the carpenter's measurements were accurate, but we do know that the measurement has been expressed correctly since it contains both a number and unit for each of the two distances.

As we move from subject to subject in physics, you will find that almost everything we measure can be described in terms of length, mass, and time. Although these quantities are not easy to define in simple language, for the present we shall base our thinking on these preliminary definitions:

Length is the distance between two points.

Mass is the quantity of matter in a body. (You will se later that this definition is much too vague. A more rigorous definition of mass will have to wait until you attain the status of "junior physicist.")

Time is the most difficult quantity to define. For the moment we will say that time measures the waiting period between events.

Let us start with units of length. For much of your life you have been using certain familiar length units. From the lists below, select the group that contains one or more units which do not measure length.

(5)

A Light-year, foot, rod, fathom.

B Yard, fathom, acre, inch.

C Inch, mile, foot, rod.

YOUR ANSWER --- C

The problem actually calls for a conversion from "mi/hr" to "km/hr." The fact that you obtained the correct numerical value for this conversion (96.6 is correct) but the wrong unit is evidence that you did not give careful attention to the three answer choices. Please be careful.

Please return to page 90 and select another answer.

YOUR ANSWER --- C

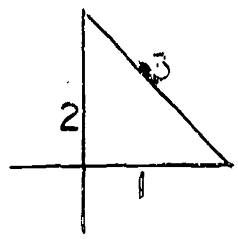

Figure 2

Line 3 is <u>not</u> the longest of the three. You made this mistake because the lengths are so similar that your eye was deceived. The eye is simply not precise enough for you to measure closely on the basis of visual inspection.

Please return to page 71 and select another answer.

YOUR ANSWER --- B

You are correct. Cancelling one factor in the numerator by any one identical factor in the denominator results in this:

$$\frac{8}{\cancel{5}} \times \frac{\cancel{4}}{1} \times \frac{\cancel{5}}{\cancel{4}} \times \frac{5}{1} = 8 \times 5 = 40$$

Now let's go back and handle the units in the sample problem the same way. The problem was to reduce 4.7 kilometers to meters.

$$4.7 \text{ km} \times 1{,}000 \text{ m/km} = ???$$

Since the unit "km" appears in both the numerator and denominator, there is only one thing left to do with it.

Please turn to page 17.

YOUR ANSWER --- B

You are correct. Let's consider a typical set of figures. Suppose that you counted 69 pulse beats during the 60-second interval. To determine the number of beats in each 10-second interval from this figure we must divide it by 6, since there are six 10-second intervals in 60 seconds. Thus, 69/6 = 11.5 beats in every 10-second interval. But you can't count half-beats with any degree of accuracy; therefore, when you timed your pulse during the 10-second interval, you would have called it <u>either</u> 11 beats or 12 beats per 10-second interval. Using either of these to determine the number of beats per minute, you would obtain:

$$11\frac{\text{beats}}{\text{10-sec int.}} \times 6\frac{\text{10-sec int.}}{\text{minute}} = 66 \text{ beats per minute}$$

$$12\frac{\text{beats}}{\text{10-sec int.}} \times 6\frac{\text{10-sec int.}}{\text{minute}} = 72 \text{ beats per minute}$$

So, in this case, timing over a shorter interval permits an error of plus of minus 3 beats in each minute, while timing over the full 60-second interval can cause, at the most, an error of only 1 beat.

In a later lesson, we shall have more to say about measurement errors and the methods that are used to take them into account. This lesson is now complete. <u>Read the summary very carefully</u>. Memorize your notebook data. When you have done this, you may take the test on Lesson 1.

Please go on to page 32.

SUMMARY

To progress from a primitive descriptive study to a highly precise and technologically useful field, a science must develop systems of measurement and suitable measuring instruments. A measurement must be expressed in terms of a number and a unit. The common English system units such as the foot, mile, and yard have been largely replaced in scientific work by the meter and its subdivisions and multiples. In the metric system, of which the meter is a fundamental part, the basic unit of weight is the gram and the basic unit of time is the mean solar second. We introduce the English units (foot, pound, inch, etc.) only to give you the "feel" of the relative sizes of the metric units. You are urged to memorize the simple conversion factors you have copied into your notebook. With these relationships forming a part of your "vocabulary," expressions in the metric system will become more meaningful to you.

Units may be handled like numerals in performing conversions within a given syste, or from one system to the other. They may be multiplied, divided or cancelled, squared, cubed, and so on. Very often, knowledge of the correct initial units as well as the desired final units in a conversion problem will give you all the information you need to decide on the proper arithmetic operation.

Please go on to page 33.

A time interval is measured in terms of the number of seconds, minutes, or hours between two events. In calculating time intervals on a 12-hour clock, it is important to remember that two such intervals make up one 24-hour day.

The beginner in physics tends to confuse mass and weight. Mass is the quantity of matter in a body. The mass of a given object is constant regardless of its location or its proximity to other objects. Weight is a measure of the gravitational pull exerted by a planet on a mass. The planet Earth is our normal reference for measuring weight. If a group of objects are all weighed in a specific location, we can say with confidence that the weights thus obtained are strictly proportional to the respective masses. That is, if Body B has twice the mass of Body A, then Body B weighs twice as much as Body A provided the weighings are performed in the same place. If we go to a different location, the weight may be different, but the mass will still be the same. Common metric units of mass are the kilogram (kg), gram (g), milligram (mg), and microgram (ug). Normally 1 kg weighs 2.2 lbs.

You are now ready to take a final examination on this lesson or go on directly to the next lesson.

Review your notes thoroughly before going on. Then, please turn to page 34.

You have now completed the study portion of Lesson I and your Study Guide Computer Card and A V Computer Card should be properly punched in accordance with your performance in this Lesson.

You should now proceed to complete your homework reading and problem assignment. The problem solutions must be clearly written out on 8½" x 11" ruled, white paper, and then submitted with your name, date, and identification number. Your instructor will grade your problem work in terms of an objective preselected scale on a Problem Evaluation Computer Card and add this result to your computer profile.

You are eligible for the Post Test for this Lesson only after your homework problem solutions have been submitted. You may then request the Post Test Computer Card.

Upon completion of the Post Test, you may prepare for the next Lesson by requesting the appropriate:

1. Study Guide
2. Program Control Matrix
3. set of computer cards for the Lesson
4. audio tape

If films or other visual aids are needed for this Lesson, you will be so informed when you reach the point where they are required. Requisition these aids as you reach them.

Good Luck!

YOUR ANSWER --- B

You're going the wrong way!

If 454 g weigh 1 lb, then you would need 10 times that many grams to weigh 10 lbs. You divided by 10 instead of mutliplying.

Please return to page 54 and select the right answer.

YOUR ANSWER --- A

You should have read the question carefully. There are 60 seconds in a minute. You can write it this way: "60 sec/min." But there certainly are more than 60 seconds in an hour.

Please return to page 68 and select another answer.

YOUR ANSWER --- B

You are correct. The ratio of final mass to initial mass is $4m/m = 4/1$ or 4:1, so the ratio of final to initial weight must also be 4:1. The initial weight is given as 2 lbs, hence the final weight must be 4 x 2 lbs = 8 lbs.

<u>Weight</u> and <u>mass</u> are <u>not</u> the same. They are really different quantities. Mass measures the amount of matter in a body while weight measures the gravitational pull by the planet on which the body is resting. If you carried a certain mass <u>m</u> from here to the Moon, the quantity of matter in it would not change by being transported through space. Thus, the mass <u>m</u> would still be the same on the Moon as on Earth. But, the gravitational pull of the Moon is much less than that of the Earth; therefore, the weight of any object must be less on the Moon than on the Earth.

That seems clear enough. So, which of the following statements contains the essence of the explanation above?

(29)

A Transporting an object from one planet to another would change both the weight and mass of the object.

B For a given body, mass is constant but weight may be variable.

C For a specific object, weight is constant but mass may vary from place to place.

YOUR ANSWER --- B

You are correct. When the quantities are set up properly it is hard to make a mistake, isn't it?

$$60 \text{ mi/hr} \times 1.61 \text{ km/mi} = 96.6 \text{ km/hr}$$

Practice in unit manipulation is so essential that we want you to do every one of the problems below. Don't hesitate to spend all the time you need.

Group 1	Group 2	Group 3
8 m = 314.96 in	36 in = 91.44 cm	80.5 km = 50 mi
25.4 cm = 10 in	49.2 ft = 15 m	10 yds = 9.15 m
20 m = 65.6 ft	10.0 m = 32.8 ft	16 km = 16,000 m

Now select the correct answer below:

(22)

A Groups 1 and 2 are entirely correct but Group 3 is incorrect.

B Groups 1 and 3 are entirely correct but Group 2 is incorrect.

C Groups 2 and 3 are entirely correct but Group 1 is incorrect.

D All groups are entirely correct.

YOUR ANSWER --- B

You are correct. Any problem in division may be converted to a problem in multiplication by using the reciprocal of the divisor as a multiplier. Thus:

$$\frac{mm}{mm/m} = \cancel{mm} \times m/\cancel{mm} = m$$

Before continuing, please turn to page 111.

The next example uses the same rule. Apply it carefully.

Which of the expressions below is correctly set up to convert 6,640 cm to kilometers? Refer to your notebook for the conversion figures.

(16)

A $\dfrac{6{,}640 \text{ cm} \times 100 \text{ cm/m}}{1{,}000 \text{ m/km}}$

B $\dfrac{6{,}640 \text{ cm} \times 1{,}000 \text{ m/km}}{100 \text{ cm/m}}$

C $\dfrac{6{,}640 \text{ cm}}{1{,}000 \text{ m/km} \times 100 \text{ cm/m}}$

YOUR ANSWER --- B

You are correct. Since there are 60 sec/min and 60 min/hr, the number of sec/hr can be immediately obtained by multiplication. Thus:

$$60 \text{ sec/min} \times 60 \text{ min/hr} = 3{,}600 \text{ sec/hr}$$

Go on to page 41.

Since the common time units are used every day, we shall assume that you have the "feel" of the second and the minute. A time measurement is generally used to answer one of two questions: (a) How long did it take? (b) When did it occur?

The first question is answered by stating a time interval, for instance: "The wheel takes 5 seconds to make one complete rotation." The second question is answered by a statement such as: "The wheel reached its top speed at 4:31 p.m."

We might use a stop watch for the first measurement, starting it when the wheel is in some pre-selected position and stopping it when the wheel has returned to exactly the same position after one rotation. The stop watch measures the interval of time. For the second kind of time measurement, we need an accurate clock that will read the exact time of an event. Actually, however, the two measurements are much the same in that the clock really tells you the interval between some arbitrary starting time, like midnight of the day before, and the time of the event you observe.

Which of the following statements is true?

(24)

A The interval between noon and midnight on the same day is 12 hours.

B The interval between midnight on one day and midnight on the day after is 12 hours.

C The interval from 1:00 p.m. on one day to 6:00 p.m. on the same day is 6 hours.

YOUR ANSWER --- C

It is true that the definition is simple, but it certainly is not rigorous. In physics, a rigorous definition is one that permits of only one interpretation and excludes all others. This definition may be interpreted in several ways. For example, just what does the word "quantity" mean? Is it the space occupied by the body? Is it the weight of the body? Is it the surface area of the body?

Since we can't be quite sure of what someone means by "quantity," we must conclude that a definition of mass which uses this word is not rigorous.

Please return to page 77 and select another answer.

YOUR ANSWER --- B

Incorrect. The mass of the ball increases in the same ratio as the weight.

$$\text{Ratio fo increase} = \frac{\text{New weight}}{\text{Original weight}} = \frac{30 \text{ oz}}{3 \text{ oz}} = \frac{10}{1}$$

Since the original mass was m, the new mass cannot be 30 m. What is the ratio of the final weight 30 oz to the original weight 3 oz?

Please return to page 26 and select the correct answer.

YOUR ANSWER --- B

You've moved the decimal point in the right direction but not far enough. There are 265 km in 265,000 meters, but this question requires you to find the number of km in 265,000 centimeters.

Watch those abbreviations!

Please return to page 9 and select another answer.

YOUR ANSWER --- A

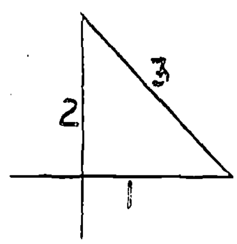

Figure 2

Line 1 is <u>not</u> the longest of the three. You made this mistake because the lengths are so similar that your eye was deceived. The eye is not precise enough for you to measure closely on the basis of visual inspection.

Please return to page 71 and select another answer.

YOUR ANSWER --- A

You are correct. Good work! You recognized that 5,280 feet must be divided by 100 in order to obtain the number of feet in 1/100 of a mile. That is:

$$\frac{5,280}{100} = 52.8 \text{ feet in } 1/100 \text{ of a mile.}$$

Since the yard is 3 times as large as the foot, any given distance will contain 1/3 as many yards as it contains feet. Hence, to find the number of yars in 1/100 of a mile, we divide 52.8 by 3.

$$\frac{52.8}{3} = 17.6 \text{ yards in } 1/100 \text{ of a mile.}$$

Before continuing, first turn to page 110.

In 1791, the new government of France created a more logical system of weights and measures based upon <u>decimal</u> subdivisions. For this new system, the French designated the basic unit of length called a <u>meter</u>, to be one ten-millionth of the distance along the prime meridian from the North Pole to the Equator. We can easily approximate the size of the meter this way:

The circumference of the earth is roughly 24,000 miles. The distance from Pole to Equator is 1/4 of this or 6,000 miles. Using 5,000 feet to the mile as an approximation, the number of feet between Pole and Equator is about 30,000,000. If the meter is one ten-millionth of this distance, then how many feet must a meter contain?

(7)

A 3/10 feet

B 3 feet

C 30 feet

YOUR ANSWER --- C

You are correct. Completing the problem, we have:

$$0.025 \text{ km} \times 1{,}000 \text{ } \cancel{\text{m}}/\text{km} \times 100 \text{ cm}/\cancel{\text{m}} = 2{,}500 \text{ cm}$$

Let's see how this kind of unit manipulation works out in a division conversion such as changing 8,600 mm to meters. In this case, since the meter is so much larger than the millimeter it will require far <u>fewer</u> meters than millimeters to fill a given distance. Thus, division is indicated:

$$\frac{8{,}600 \text{ mm}}{1{,}000 \text{ mm/m}}$$

Here we are making use of our knowledge that there are 1,000 mm in each m. Of course, 8,600 divided by 1,000 is 8.6. This is the numerical part of the answer. But what is the result of dividing the unit part of the answer:

$$\frac{\text{mm}}{\text{mm/m}}$$

(15)

A 1/m.

B m.

C m/mm.

YOUR ANSWER --- A

This will not give you an answer in kilometers. To prove our point, we need not use the numbers at all. All we need do is set up the units.

$$\frac{cm \times cm/m}{m/km}$$

Using the reciprocal rule, we invert the divisor and write:

$$cm \times cm/m \times km/m$$

Nothing cancels. That in itself is a bad sign. Furthermore, when the units are multiplied out we obtain $cm^2 km/m^2$. This combination means nothing. It certainly doesn't reduce to km, does it? Hence, the original expression was wrong.

Please return to page 39, and then, before making another choice, look over the units to see if any of them can be cancelled.

YOUR ANSWER --- B

This would be a poor way to write board measurements. The carpenter has taken the trouble to write the unit for the width of the board but has omitted the unit for the length. The board might by 3 yards long. How can you tell if the unit is omitted? It is the duty of the person taking the measurement to specify the unit he is using. A number without a unit is "undressed" if this number represents a measurement.

Please return to page 91 and select another answer.

YOUR ANSWER --- B

It is essential that you realize how important notes are to you. A notebook is your record of progress; you need it as a sourcebook for future study. Unless you maintain it with scrupulous care it will hinder rather than help. A poorly kept notebook can be a source of misinformation.

NOTEBOOK CHECK errors may cost a number of unnecessary wrong-answer counts because you may be offered 5 or more choices as answers. If you guess at answers because of lack of precision in note-taking, you may guess wrong often before arriving at the right response. By copying the notes with exactness, you will inevitably raise your final score considerably.

You should take time now to check your notebook entry. Go on to page 93.

NOTE

This page has been inserted to maintain continuity of text material. You will find a number of such pages at necessary intervals throughout the course.

Such pages do not convey lesson information and should be ignored by the student.

YOUR ANSWER --- B

You can't find the correct interval merely by counting hours as read on the clock. In this case, if you count 10:00, 11:00, 12:00, 1:00, 2:00, 3:00 you come out with 6 time-readings. But this is not the interval. Count the individual intervals between each time-reading and the next, and add these intervals.

Please return to page 83 and select another answer.

YOUR ANSWER --- C

You've got it backwards! The mass of a body depends only upon the quantity of matter it contains. Consider the mass as a tightly sealed package of atoms and molecules. If you move this pacakge from the Earth to Venus or Jupiter, do you change the number, kind or arrangement of these atoms? Of course you don't.

If, however, you carry the package to another planet what are the chances that this planet would exert exactly the same gravitational pull on the object? Very, very small indeed! Unless it were a twin of the Earth, the gravitational pull would be very different.

Please return to page 37 and select another answer.

YOUR ANSWER --- A

You are correct. Since 1 kg weighs 2.2 lbs, we know that 6.6 kg will weigh 6.6 times more than 2.2 lbs. That is, the problem calls for multiplication. From our methods of manipulating units we know that the expression "1 kg weighs 2.2 lbs," might be written in shorthand as "2.2 lbs/kg" which really means that there are 2.2 lbs of weight per kg of mass. Then we can write out the multiplication of 6.6 x 2.2 this way:

$$2.2 \text{ lbs}/\cancel{\text{kg}} \times 6.6 \cancel{\text{kg}} = 14.52 \text{ lbs}$$

The second item in Notebook Entry 3 is "454 g weigh 1 lb." Let's see how this conversion factor is obtained. There are 1,000 g per kg or 1,000 g/kg, and there are 2.2 lbs per kg or 2.2 lbs/kg. Now let us divide 1,000 g/kg by 2.2 lbs/kg.

$$\frac{1{,}000 \text{ g/kg}}{2.2 \text{ lbs/kg}} = 1{,}000 \text{ g}/\cancel{\text{kg}} \times 1/2.2 \cancel{\text{kg}}/\text{lbs}$$

$$= \frac{1{,}000 \text{ g}}{2.2 \text{ lbs}} = 454 \text{ g/lbs}$$

All right? Then how many grams of mass are required to produce a weight of 10 lbs?

(31)

A 4,540 g.

B 45.4 g.

YOUR ANSWER --- A

This answer is not acceptable. If a watch does not keep good time, it generally has a consistent error. That is, it runs either too fast or too slowly. If the error is very slight, it might not be noticeable in a 10-second run, but in a 60-second run the chances are much better for the error to appear in the result. Actually, any small error in an ordinary watch over an interval of either 10 seconds or 60 seconds would be very difficult to spot.

Please return to page 62 and select another answer.

YOUR ANSWER --- B

You multiplied 18.25 m by 10, which shows that you think there are 10 cm in one meter. A glance at your notebook will tell you there are 100 cm per m. To convert from meters to centimeters you must multiply by 100, not by 10.

Please return to page 106 and select another answer.

YOUR ANSWER --- C

You are correct. Keep up the good work. Your notebook is of great importance to you; its value depends on the care you exercise in taking notes.

We shall work now on conversions from meters to feet, and vice versa.

Let us first determine the number of feet in a meter to a greater precision than we did before. You already know that there are <u>about</u> 3 feet in one meter. To find a more precise value, we s-all use the fact that there are 39.37 inches in one meter. Also, since there are 12 inches in one foot, we can set up the conversion this way:

$$\frac{39.37 \text{ in/m}}{12 \text{ in/ft}} = 39.37 \cancel{\text{in}}/\text{m} \times 1/12 \text{ ft}/\cancel{\text{in}}$$

Step 1 Step 2

In Step 1, since there are fewer feet per meter than there are inches per meter, we know that division is indicated. To straighten out our units, we then rewrite the expression in the <u>reciprocal</u> form as in Step 2. Then the "inch" units cancel, and we are left with feet per meter or ft/m.

Now perform the necessary arithmetic. How many feet are there in one meter? (Carry out the answer to three decimal places; then round off to two in the usual way.)

(20)

A 3.28 feet.

B 3.26 feet.

YOUR ANSWER --- C

You are correct.

Review the solutions below. If you made one or more errors in answer selections, be certain that you track down the reasons for the error. This is very important.

<u>Group 1</u>:	$2.2\ \cancel{kg} \times 1,000\ g/\cancel{kg} = 2,200\ g$	This is correct.
	$50\ \cancel{g} \times 1/1,000\ kg/\cancel{g} = 0.05\ kg$	This is correct.
	$2,270\ \cancel{g} \times 1/454\ lb/\cancel{g} = 5\ lbs$	<u>Not 50 lbs</u>, as given in the example.
<u>Group 2</u>:	$100\ \cancel{mg} \times 1/1,00\ g/\cancel{mg} = 0.1\ g$	This is correct.
	$10,000\ \cancel{\mu g} \times 1/1,000,000\ g/\cancel{\mu g} = 0.01\ g$	This is correct.
	$4.3\ \cancel{kg} \times 2.2\ lbs/\cancel{kg} = 9.46\ lbs$	This is correct; hence the entire group is correct.
<u>Group 3</u>:	$7,500\ \cancel{g} \times 1/1,000\ kg/\cancel{g} = 7.5\ kg$	<u>Not 75 kg</u> as given in the example.
	$1.37\ \cancel{g} \times 1,000\ mg/\cancel{g} = 1,370\ mg$	This is correct.
	$150\ \cancel{kg} \times 2.2\ lbs/\cancel{kg} = 330\ lbs$	<u>Not 3,300 lbs</u> as given in the example

Please go on to page 59.

Before continuing, please turn to page 114.

Before conlcuding this lesson on Measurement and Unit Systems, make a few measurements for practice. Using your centimeter scale, measure the diameter of the face of a U. S. dime. To insure accuracy, follow these two rules: (1) start from the 1 cm mark or the 10 cm mark, not the rounded, usually inaccurate end of the scale. (2) Hold the ruler on edge against the flat surface (see figure 5). This reduces a possible error due to parallax, because of thickness of the scale, an effect that is easy to demonstrate. You can hold two pencils vertically in line with each other, about 8 inches apart, one behind the other. Close one eye and squint with the other at the two pencils, placing your head in a position such that the front pencil hides the rear one. Ready? Now tilt your head to the right slightly, noting that the closer pencil seems to move to the left, exposing the farther pencil to view. Repeat by moving your head to the left. Since a scale has thickness, if you lay it flat on the dime, any movement of the head out of line will cause this apparent parallactic shift between the surface of the dime and the scale markings. Placing the scale on edge reduces the parallactic distance.

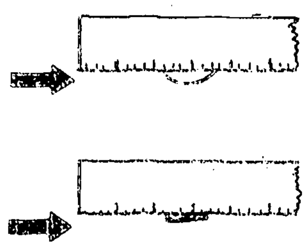

Figure 5.

Now write the diameter of the dime to the nearest whole millimeter, and then please turn to page 60.

(Use scrap paper; these are not notebook entries.)

Your written measurement should read: "The diameter of a U. S. dime is approximately 1.8 cm or 18 mm." If it doesn't, you need to be more careful.

Now measure the diameter of a U. S. quarter. Write the measured diameter in two ways: (1) in centimeters to the nearest 0.1 cm and (2) in millimeters to the nearest millimeter.

Please go on to page 61.

Your measurements should be:

(1) 2.4 cm

(2) 24 mm

Next, measure the <u>length</u> of a U. S. dollar bill in centimeters to the nearest 0.1 cm, and in millimeters to the nearest millimeter. Write down both figures.

Determine the <u>width</u> of the same bill in centimeters to the nearest 0.1 cm and in millimeters to the nearest millimeter. Write down the result.

To check your accuracy, please go on to page 62.

Your measurements should be:

Length -- 15.5 cm or 155 mm.

Width --- 6.6 cm or 66 mm.

Let's try a simple experiment in timing. For this you need a timepiece with a second hand. Find your pulse on either wrist. The best place to detect it is in the region of the wrist immediately below the thumb section of the palm. When you have located your pulse, count the number of pulse beats in 60 seconds and note the figure. Then repeat the procedure, this time counting the number of pulse beats in 10 seconds. Write the figure, then multiply it by 6. If both measurements were <u>perfect</u> (which they won't be), then the number of pulse beats in 60 seconds should be exactly equal to the number of beats in 10 seconds multiplied by 6. Which of the following answers best accounts for any discrepancy you may have obtained?

(33)

A The accuracy of the watch is better over a longer period of time.

B Since you are not measuring <u>fractions of beats</u>, any fractional error made in the 10-second count will be multiplied by 6.

C The accuracy of your count is better over a longer period of time.

YOUR ANSWER --- D

There is a correct group. Check over all the examples to find the group (or groups) that are entirely correct. You'll find the errors if you try hard enough.

Please return to page 85 and select another answer.

YOUR ANSWER --- A

If one meter contains about 3 feet, then a man 6 meters tall would be 18 feet tall. This is a rather unlikely size, : 't it?

Please return to page 107 and select another answer.

YOUR ANSWER --- C

You are correct. Very good.

Let us omit the numbers and work with the units only.

$$\frac{cm}{\frac{\cancel{m}}{km} \times \frac{cm}{\cancel{m}}} = \frac{cm}{\frac{cm}{km}}$$

In this step, we simplified the denominator by cancelling one "m" against another. Applying the reciprocal rule, this becomes:

$$\cancel{cm} \times km/\cancel{cm} = km$$

Now we see immediately that the operation will give us the correct units. Of course, arriving at the right answer will depend upon correct arithmetic operations as well as upon correct handling of units.

What fraction of a kilometer is equivalent to 6,640 cm?

(17)

A 0.0664.

B 0.00664.

YOUR ANSWER --- B

You are correct. Cancellation is like this:

$$\frac{\text{kgm} \times (\cancel{\text{m}}/\text{sec} \times \text{m/sec})}{\cancel{\text{m}}}$$

We've given quite a bit of time to length units and their manipulation. The time was well-spent, however, because we will be encountering conversions of units throughout our work in physics. Once you have developed a facility with units, you have taken a giant step in problem-solving techniques. Right now you probably feel as though you could use much more practice, but, as you will see, your facility will grow with the practice you get as we cover new topics. So for now, we will dispense with further work on unit manipulation exercises.

It is time for a notebook check. Whenever such a check is called for, refer to the appropriate item in your notebook to obtain the right answer to the check question or questions.

NOTEBOOK CHECK

Which of the following conversion groups is entirely correct?

(19)

A
1 meter (m) = 39.37 in
1 inch (in) = 2.54 cm
1 mile (mi) = 0.61 km

B
1 m = 39.37 in
1 cm = 2.54 in
1 mi = 1.61 km

C
1 m = 39.37 in
1 in = 2.54 cm
1 mi = 1.61 km

YOUR ANSWER --- D

You are correct. Here they are all worked out:

Group 1

$8\ \cancel{\text{m}} \times 39.37\ \text{in}/\cancel{\text{m}} = 314.96\ \text{in}$

$25.4\ \cancel{\text{cm}} \times 1/2.54\ \text{in}/\cancel{\text{cm}} = 10\ \text{in}$

$20\ \cancel{\text{m}} \times 3.28\ \text{ft}/\cancel{\text{m}} = 65.6\ \text{ft}$

Group 2

$36\ \cancel{\text{in}} \times 2.54\ \text{cm}/\cancel{\text{in}} = 91.44\ \text{cm}$

$49.2\ \cancel{\text{ft}} \times 1/3.28\ \text{m}/\cancel{\text{ft}} = 15\ \text{m}$

$10.0\ \cancel{\text{m}} \times 3.28\ \text{ft}/\cancel{\text{m}} = 32.8\ \text{ft}$

Group 3

$80.5\ \cancel{\text{km}} \times 1/1.61\ \text{mi}/\cancel{\text{km}} = 50\ \text{mi}$

$10\ \cancel{\text{yds}} \times 3\ \cancel{\text{ft}}/\cancel{\text{yd}} \times 1/3.28\ \text{m}/\cancel{\text{ft}} = 9.15\ \text{m}$

$16\ \text{km} \times 1{,}000\ \text{m}/\text{km} = 16{,}000\ \text{m}$

Please go on to page 68.

At this time we shall leave length units for a while and briefly discuss the common units used to measure time. Since these units are exactly the same in both the metric and English systems, there is nothing new to learn. You are quite familiar with seconds, minutes, hours, days, weeks, months, years, and centuries.

Before continuing, please turn to page 112.

We'll start with the day. We shall use the so-called mean solar day (mean stands for average). This is the time interval between high noon on one day and high noon on the next day. The mean solar day contains 24 mean solar hours; the hour contains 60 means solar minutes; and the minute contains 60 mean solar seconds. For brevity, we omit the "mean solar" part of each of these.

How many seconds are there in one hour?

(23)

A 60 seconds.

B 3,600 seconds.

C 86,400 seconds.

YOUR ANSWER --- A

Let's see what confused you. You started with 18.25 meters. The meter is a large unit compared to the centimeter. Hence, you will need many more centimeters to fill a certain length than there were meters originally. True enough, there are 100 cm per m; but you divided 18.25 by 100 to obtain 0.1825. Notice that you ended up with fewer rather than more centimeters. Can you now see your error?

Please return to page 106 and select another answer.

YOUR ANSWER --- C

You are correct. The centimeter is a small unit compared to the meter, so there will be 100 times as many centimeters as there are meters in a given length. Thus, 18.25 m x 100 cm/m = 1,825 cm.

To give yourself some practice with metric length units and to evaluate your understanding thus far, examine the following groups of metric conversions. Only <u>one</u> of these three groups contains three correct statements. Which group is completely correct?

(11)

	87.5 m = 8,750 cm
A	4,700 m = 4.7 km
	6.8 m = 680 mm
	1,800 mm = 1.8 m
B	3.5 km = 3,500 m
	64.8 cm = 648 mm
	36.6 cm = 366 mm
C	1,650 mm = 16.5 m
	165 km = 165,000 m

YOUR ANSWER --- A

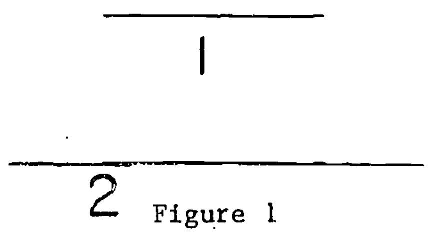

Figure 1

You are correct. The difference between the lengths of line 1 and line 2 is so much that you can easily tell by visual inspection, that line 2 is longer than line 1.

Now compare the lengths of the three lines in the diagram below.

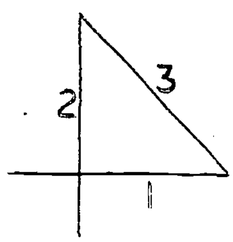

Figure 2

(2)

A Line 1 is the longest.

B Line 2 is the longest.

C Line 3 is the longest.

D I cannot tell which is the longest without using a ruler or scale.

YOUR ANSWER --- B

You are correct. This group contains no errors.

$$\frac{1{,}800 \text{ mm}}{1{,}000 \text{ mm/m}} = 1.8 \text{ m}$$

$$3.5 \text{ km} \times 1{,}000 \text{ m/km} = 3{,}500 \text{ m}$$

$$64.8 \text{ cm} \times 10 \text{ mm/cm} = 648 \text{ mm}$$

You have probably noticed that we have been including the unit abbreviations in our conversion calculations. Consider this example: Convert 4.7 km to meters.

$$4.7 \text{ km} \times 1{,}000 \text{ m/km} = ???$$

Units may be handled just like numbers, in that they may be multiplied, divided, and cancelled in the same way.

In this example, what would you do with the units "km"?

(12)

A Cancel them.

B Multiply them.

YOUR ANSWER ---- B

This does not reduce to kilometers. The easiest way to prove this expression incorrect is to use the units without the numbers.

$$\frac{cm \times m/km}{cm/m}$$

The reciprocal rule tells us to invert the denominator and then multiply. So:

$$cm \times m/km \times m/cm$$

One "cm" cancels another "cm" and we are left with m^2/km. The answer cannot be reduced any further. Hence we have not converted from centimeters to kilometers as called for in the problem.

Please return to page 39 and look over the units again to find the correct expression.

YOUR ANSWER --- C.

Perhaps you think that more items in the final unit would be unduly complicated. Or maybe you just cancelled the "m" below the line against the "m" above the line and forgot that the fraction m/sec is squared. Try writing out the equation in full and then cancelling.

Please return to page 15 and select another answer.

YOUR ANSWER --- C

Not quite. To obtain the correct interval, visualize the clock face and note that the hour hand moves this way:

1:00 to 2:00 p.m.	----	1 hour
2:00 to 3:00 p.m.	----	1 hour
3:00 to 4:00 p.m.	----	1 hour
4:00 to 5:00 p.m.	----	1 hour
5:00 to 6:00 p.m.	----	1 hour
Total		5 hours

Thus, in a case like this, the interval can be obtained by subtracting the earlier time from the later one.

Please return to page 41 and select another answer.

YOUR ANSWER --- B

You are correct. The yard, inch, and fathom (6 feet) are all length units. The acre, however, is not a length unit. It is a measure of area and contains roughly 43,560 square feet.

The units of length mentioned thus far are English System units. The English System is used in the United States by the carpet-layer, the surveyor, and by most engineers. But it is awkward since tedious calculations are needed to convert from large to small units and vice versa.

For example, there are 5,280 feet in one mile and 3 feet in one yard. Using these figures, determine the number of yards in 1/100 of a mile.

(6)

A 17.6 yards.

B 158.4 yards.

C 176 yards.

YOUR ANSWER --- C

You are correct. When in doubt about time intervals of this nature write them out like this:

10
    1 hour
11
    1 hour
12
    1 hour
1
    1 hour
2
    1 hour
3

Total 5 hours

There will be much use for time units and time intervals in subsequent work, but now let us go on to the next basic quantity for which there are both English and Metric units: mass. Earlier we tentatively defined mass as the quantity of matter in a body. How did we then qualify this definition?

(26)

A We said that this definition was too vague.

B We said that this definition was incorrect.

C We said that this definition was simple and rigorous.

YOUR ANSWER --- B

You are correct So long as you don't disturb the total quantity of matter in an object, you can heat it, squeeze it, alter it, shape, or move it anywhere you like without changing its mass. To describe this, we say that mass is a constant quantity. Heating, squeezing, or changing the shape of an object doesn't usually change the weight either, but moving it to a new location may definitely do so. Weight is therefore variable since it depends on gravitational pull as well as on mass.

Consider for a moment the English system of weights We measure weight by means of units such as the ounce, the pound, and the ton. THESE ARE NOT UNITS OF MASS. The basic unit of mass is a slug in the English system, but this unit is so cumbersome and difficult to use that we ask you to forget it at once. We mention it only because you may run into it in your outside reading.

The metric system is used in most scientific work throughout the world. In this system, the basic unit of mass is the gram (g). A gram is the mass of a cubic centimeter of water--and that can be found anywhere. Other metric units of mass are shown below.

NOTEBOOK ENTRY

2. Table of Metric Masses

1 kilogram (kg)	=	1,000 grams (g)
1 gram (g)	=	1,000 milligrams (mg)
1 gram (g)	=	1,000,000 micrograms (μg)

Please go on to page 79.

Obviously, the unit representing the largest mass is the kilogram (kg) and the unit representing the smallest mass is the microgram (μg). (The symbol "μ" is the Greek letter mu which, in this connection, means one one-millionth of.) Thus, one microgram (μg) is one one-millionth of a gram. A metric ton is 1,000 kilograms.

So that you can get some notion of the weight of 1 kilogram, refer to Figure 4 Here we show a pan balance of the type you have seen used in general science and in the drug store. On the left pan, we have placed a mass of 1 kilogram. If we now add 2.2 lbs of weight to the right pan, we find that perfect balance is obtained. Therefore, we can say that a mass of 1 kilogram weighs 2.2 lbs. In Europe mass "weights" are used in commerce, but the size of mass units is such that in scientific work, the gram and its multiples are units of MASS. On a pan balance, the equality mentioned above always holds, but with spring scales, where weight depends on gravity, it is not always true, as on the Moon. There a 1 kg mass would weigh only about 7 ozs if weighed on spring scales.

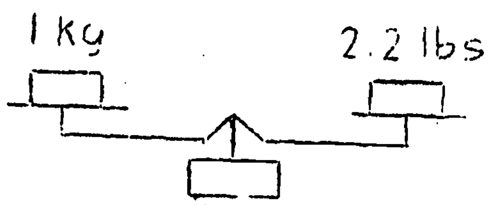

Figure 4

NOTEBOOK ENTRY

3. Mass Conversion Factor

1 kg of mass weighs 2.2 lbs
454 g of mass weigh 1.0 lb

Using the table, determine the weight in pounds of 6.6 kg.

(30)

A 14.52 lbs.

B 3 lbs.

YOUR ANSWER --- C

We are not going to tell you *why* the selection you made is wrong. You must do all problems to be certain of the right answer.

Please return to page 38 and select another answer

YOUR ANSWER --- C

Let's review these ideas. The mass of a body is defined tentatively as the amount of matter in the body. Actually, the weight of a body in a given location depends upon the mass of the body. That is, weight is a measure of the force of gravitation that acts on the matter in an object. You weigh more than your briefcase because you have more matter in your body and the Earth's gravity therefore pulls you downward with a greater force. If your body happens to contain exactly twice as much matter as your briefcase, then the Earth will pull on you twice as hard as on your briefcase, and therefore you will weigh twice as much as the briefcase.

Suppose a boy weighs 140 lbs and his small brother weighs 70 lbs. The ratio of their weights is 140/70 or 2 to 1. From what we have said, the ratio of their masses would also be 2 to 1 (or 2:1). This is exactly what is meant by a direct proportion. If _a_ is directly proportional to _b_, then if we double _b_, _a_ must double; if we triple _b_, then _a_ must triple; if we quadruple _b_ then _a_ must quadruple; and so on.

Returning to our problem now, we find that the original mass was _m_, and the total mass after loading was 4m. The ratio of final mass to original mass is 4m/m or 4:1. Hence, the ratio of final weight to original weight must also be 4:1.

Please return to page 98 and select another answer.

YOUR ANSWER --- B

We are not going to tell you why the selection you made is incorrect You must do all problems to be certain of selecting the correct answer.

Please return to page 38 and select another answer.

YOUR ANSWER --- A

You are correct. The hour moves over 12 one-hour intervals in passing from 12:00 noon to 12:00 midnight on the same day.

What is the interval between 10:00 a.m. and 3 p.m. on the same day?

(25)

A 7 hours.

B 6 hours.

C 5 hours

YOUR ANSWER --- B

The difference in lengths of the two lines is so obvious that, in choosing line ! as the longer of the two lines you may have made an error.

Please return to page 4 and select another answer.

YOUR ANSWER --- A

You are correct. You probably arrived at the right answer by simple logic. If you wanted to write out the solution showing the unit relationships, you could do it this way:

$$10 \text{ lbs} \times 454 \text{ g/lbs} = 4{,}540 \text{ g.}$$

All of the problems given below should be done carefully. The practicing you do is necessary to develop ease in handling units and conversions.

Do each of the problems in each of the groups; then select the correct answer below.

Group 1	Group 2	Group 3
2.2 kg = 2,200 g	100 mg = 0.1 g	7,500 g = 75 kg
50 g = 0.05 kg	10,000 µg = 0.01 g	1.37 g = 1,370 mg
2,270 g = 50 lbs	4.3 kg = 9.46 lbs	150 kg = 3,300 lbs

Which of the following statements is true?

(32)

A Group 1 is <u>entirely</u> correct.

B Groups 2 and 3 are both <u>entirely</u> correct.

C Group 2 is <u>entirely</u> correct.

D None of the groups is <u>entirely</u> correct.

YOUR ANSWER --- A

You had the right idea, but since the distance between the North Pole and the Equator along the prime meridian is roughly 30,000,000 feet, the meter is one ten-millionth of this distance. Therefore, to find the number of feet in one meter, you must divide 30,000,000 by 10,000,000. Your answer indicates that you divided by 100,000,000 making your result 1/10 as large as it should be.

Please return to page 46 and select another answer.

YOUR ANSWER --- C

First of all, this answer has very little meaning when you stop to think it over. As long as you don't become fatigued, you can maintain the same counting accuracy over various intervals of time.

Carried to an extreme, an answer opposite to the one you selected would be substantially more appropriate. For example, suppose you were handed a small pot containing ping-pong balls and were asked to count them. Say you count a total of 37 balls in the pot. Now imagine that you are asked to count the ping-pong balls in a bathtub. Since you will be counting over a much longer period of time, your chance for error becomes greater due to fatigue, carelessness, etc.

Please return to page 62 and select another answer.

YOUR ANSWER --- B

You seem to have inverted your units. There are 1,000 meters in 1 kilometer, not the other way around. If you multiplied out your units, you would get something like this:

$$0.025 \text{ km} \times 1{,}000 \text{ km/m} \times 100 \text{ cm/m} =$$

$$0.025 \times 1{,}000 \times 100 \text{ km} \times \text{km/m} \times \text{cm} =$$

$$2{,}500 \text{ (km)}^2\text{cm/(m)}^2$$

This is really self-contradictory.

Please return to page 17 and select another answer.

YOUR ANSWER --- D

You cancelled very enthusiastically; but you missed a little "2." The fraction inside the parenthesis, m/sec, is squared. Try writing out the equation in full and then cancelling.

Please return to page 15 and select another answer.

YOUR ANSWER --- A

You are correct. 39.37 divided by 12 rounds out to 3.28. Add as your fourth item under "Conversions" in your notebook, "1 meter (m) = 3.28 ft."

Now suppose we tackle the following problem. In this country, one of our track events is the 100-yard dash; in France, they run the 100-meter dash. Which is the greater distance?

There are several ways to handle this. As you look at your conversion chart, you will notice that the relationship "1 meter (m) = 3.28 ft" is the most useful here. We can write:

1 yard = 3 ft, so 100 yards = 300 feet

and 1 m = 3.28 ft, so 100 m = 328 feet

Clearly, the 100-meter dash is a somewhat longer run than the 100-yard dash.

Now try on your own. The speed limit on the New York Thruway is 60 miles per hour. If you were driving a foreign car whose speedometer read "kilometers per hour," what would the speedometer read when you were traveling at the speed limit?

(21)

A 37.3 km/hr.

B 96.6 km/hr.

C 96.6 mi/hr.

YOUR ANSWER --- B

You are correct. The lengths of the lines are identical. The scale was not "fooled" by the presence of the converging and diverging short lines at the ends of each of the long ones. Here again we see that we cannot rely upon our senses for precise information about distances or lengths.

Every true measurement consists of two distinct parts. First, it contains a number that tells you how much you have of what you are measuring. Second, it contains a unit or a standard of the particular dimension being measured. The width of a sheet of typing paper is 8½ inches. In this measurement, "8½" is the number and the inch is the unit or standard of length. A bag of sugar weighs 5 pounds; here "5" is the number and the pound (lb.) is the unit or standard of weight.

A piece of board is being measured by a carpenter. He writes down its length and width. Which of the following would you expect to see if he wrote the measurements properly?

(4)

A The board is 3 feet long and 6 inches wide.

B The length of the board is 3; its width is 6 inches.

YOUR ANSWER --- A

It is essential that you realize how important notes are to you. A notebook is your record of progress; you need it as a sourcebook for future study. Unless you maintain it with scrupulous care it will hinder rather than help. A poorly kept notebook can be a source of misinformation.

NOTEBOOK CHECK errors may cost a number of unnecessary wrong-answer counts because you may be offered 5 or more choices as answers. If you guess at answers because of lack of precision in note-taking, you may guess wrong often before arriving at the right response. By copying the notes with exactness, you will inevitably raise your final score considerably.

You should take time now to check your notebook entry. Go on to page 93.

Table of Metric Lengths

1 kilometer (km) = 1,000 meters (m)
1 meter = standard of length
1 decimeter (dm) = 0.1 meter
1 centimeter (cm) = 0.01 meter
1 millimeter (mm) = 0.001 meter

Conversions

1 meter (m) = 39.37 inches
1 inch (in) = 2.54 cm
1 mile (mi) = 1.61 km

If you are certain that your notebook is correct, then please return to page 66 and select another answer.

YOUR ANSWER --- B

One of these groups contains an error. Work through the examples of Groups 2 and 3 once again You'll find the errors.

Please return to page 85 and select another answer.

YOUR ANSWER --- B

Are you sure? The hour hand of a clock starting at 12:00 midnight on a given day will move through 12 hours before it again arrives at 12:00 o'clock. But this second 12:00 o'clock reading represents noon of the following day. In order to arrive at 12:00 midnight of the next day, the hour hand must move through a 12-hour interval once again, making a total of 24 hours between midnight one day and midnight the next day.

Please return to page 41 and select another answer.

YOUR ANSWER --- B

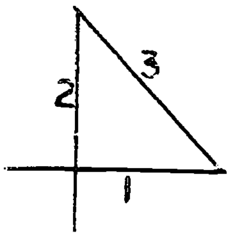

Figure 2

Line 2 is <u>not</u> the longest of the three. You made this mistake because the lengths are so similar that your eye was deceived. The eye is not precise enough for you to measure closely on the basis of visual inspection.

Please return to page 71 and select another answer.

YOUR ANSWER --- A

Remember the rules. The mass of a body depends only upon the quantity of matter it contains. Consider the mass as a tightly sealed package of atoms and molecules. If you move this package from the Earth to Mars or Venus, do you change the number, kind, or arrangement of these atoms? Of course not.

On the other hand, if you carry the package to another planet, would the gravitational pull of that planet be the same as the Earth's original pull? Unless the new planet had the same mass as Earth the pull would certainly be different.

Thus, your answer is only half-right. You should now recognize your error.

Please return to page 37 and select another answer.

YOUR ANSWER --- A

You are correct. We can show it this way:

$$\text{Ratio of increase} = \frac{\text{New weight}}{\text{Original weight}} = \frac{30 \text{ oz}}{3 \text{ oz}} = \frac{10}{1}$$

To strengthen your understanding of the relationship between mass and weight, try another problem.

A small cart has a mass <u>m</u> and weighs 2 pounds (lbs). We now load the cart with three additional masses, each equal to <u>m</u>. What will the loaded cart weigh?

(28)

A 6 lbs.

B 8 lbs.

C I'm not sure I understand this relationship.

YOUR ANSWER --- A

We are not going to tell you why your selection is not right. You must do all problems to select the correct answer.

Please return to page 38 and select another answer.

YOUR ANSWER --- B

One meter contains about 3 feet. A man who is 3 meters tall would be 9 feet tall. Even a very tall man seldom reaches these proportions.

Please return to page 102 and select another answer.

YOUR ANSWER --- A

Did you subtract 3:00 from 10:00 to get this answer? If you did, you're not giving enough thought to the actual situation. You aren't connecting the hours properly. An interval cannot always be obtained by subtracting a later time reading from an earlier one.

Please return to page 83 and select another answer.

YOUR ANSWER --- A

This isn't bad; but you did forget that both terms of the fraction m/sec are squared. Try writing out the equation in full and then cancelling

Please return to page 15 and select another answer.

YOUR ANSWER --- B

Let's see why you figured it that way. When 6,640 is divided first by 1,000 and then 100, the combined divisor is 100,000. Hence, the decimal point must be moved 5 places to the left. How many places did you move it?

Please return to page 65 and select another answer.

YOUR ANSWER --- A

An example using simple numerical quantities will show you the trouble. In the division $\frac{mm}{mm/m}$ you are being asked to divide a whole number (mm) by a fraction (mm/m). Let us say that the whole number for our illustration will be 12 and that the fractional divisor is to be 3/4. Hence, the operation to be performed is:

$$\frac{12}{3/4}$$

The rules of arithmetic tell us that 12 <u>divided</u> by 3/4 is the equivalent of 12 <u>multiplied</u> by 4/3. In general, any division may be changed to a multiplication by using the <u>reciprocal</u> of the divisor as the multiplier. Here are some examples:

$\frac{18}{2/3}$ may be written 18 x 3/2 which equals 27.

$\frac{81}{9/5}$ may be written as 81 x 5/9 which equals 45.

$\frac{ab}{a/b}$ may be written as ab x b/a which equals b^2.

In getting your answer, you did not follow this rule. You cancelled "mm" against "mm," then figured the answer as 1/m.

Please return to page 47 and select another answer.

YOUR ANSWER --- C

There is an error in the second problem.

$$\frac{1{,}650 \text{ mm}}{1{,}000 \text{ mm/m}} = 1.65 \text{ m}$$

This does not correspond with the answer to this problem given in the group above. Since 1 m contains 1,000 mm, we must divide 1,650 by 1,000. The wrong answer above is the result of erroneously dividing 1,650 by <u>100</u>.

Please return to page 70 and select another answer.

YOUR ANSWER --- A

You are correct. The best way to handle this is to convert the 265,000 cm to meters as a first step. That is, since there are 100 cm per m, 265,000 cm = 2,650 m. Next, to convert 2,650 m to kilometers, divide by 1,000 since there are 1,000 m per km. Thus:

$$2{,}650 \text{ m} = \frac{2{,}650 \text{ m}}{1{,}000 \text{ m/km}} = 2.65 \text{ km}$$

Try another. When you convert 18.25 m to centimeters, what do you get?

(10)

A 0.1825 cm.

B 182.5 cm.

C 1,825 cm.

YOUR ANSWER --- B

You are correct. One-fourth of the circumference of the earth is roughly 6,000 miles. Assuming that there are approximately 5,000 feet in a mile, then the distance from Pole to Equator is 6,000 x 5,000 = 30,000,000 feet. Taking 1/10,000,000 of this distance or 30,000,000/10,000,000 we obtain 3 feet in one meter.

About how many meters tall would you say a good-sized man is?

(8)

A 6 meters.

B 3 meters.

C 2 meters.

YOUR ANSWER --- C

No. The unit that probably tripped you up was the <u>rod</u>. The rod is a unit of length measure which is nearly obsolete in our times, but which still appears in tables of measurements. The rod is approximately 16½ feet in length. Since this length measure is of no value to the scientist, you need not memorize its foot-equivalent.

Please return to page 27 and select another answer.

YOUR ANSWER --- A

There is an error in Group 1. Work through these examples once more--carefully. You'll find the error.

Please return to page 85 and select another answer.

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Articulated Multimedia Physics

Lesson 1 Tape Segment 1

WORKSHEET

1. What scientist first suggested the use of a spectral line method for defining the standard meter?

   A Albert Einstein.
   B Isaac Newton.
   C Galileo.
   D Albert Michelson.
   E Robert Oppenheimer.

2. The gas used for the spectroscopic definition of the meter is

   A argon.
   B krypton
   C neon.
   D oxygen.
   E helium.

3. In what country is the platinum-iridium standard meter now stored?

   A United States.
   B Germany.
   C France.
   D Switzerland.
   E England.

4. What optical device is often used to disperse light into a spectrum useful for wavelength measurements?

   A A refraction grating.
   B An opaque glass triangle.
   C A circular glass prism.
   D A motionless mirror.
   E A triangular glass prism.

5. The terrestrial method used for defining the standard meter has the shortcoming that

   A it is almost impossible to phrase such a definition.
   B the earth is too large.
   C the measurement is difficult to reproduce accurately.
   D the earth is not a perfect sphere.
   E the standard meter is too small to use the earth as a basis for defining it.

(Please return to page 46 of the Study Guide and continue with the lesson)

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Articulated Multimedia Physics

Lesson 1 Tape Segment 2

WORKSHEET

6. The reciprocal of 10 is

A 10/1
B 0.1
C 10/2
D 0.01
E None of the above.

7. A reciprocal of any number may be defined as

A the number divided by one.
B ten over the number.
C one tenth of the number.
D one over the number.
E none of the above.

8. The reciprocal of the product xy is

A 1/xy
B x/y
C y/x
D xy/1
E. none of the above.

9. The reciprocal of m^2/sec is

A $m^2 \times sec^2$

B m/sec^2

C sec/m

D $\frac{1}{m^2 sec}$

E. none of the above.

(Please return to page 39 of the Study Guide to continue with the lesson)

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Articulated Multimedia Physics

Lesson 1 Tape Segment 3

WORKSHEET

10. How many seconds are there in the mean solar day?

A 60
B 8,640
C 86,400
D 860,400
E none of these is correct.

11. Which of the following statements about the earth is true?

A The time required for one rotation of the earth on its axis is very slowly increasing.

B The earth is a perfect sphere.

C Every solar year is the same length as every other solar year.

D The most precise way to define a unit of time is to base this unit on the steady rotation of the earth.

E There are 3,600 seconds in a mean solar year.

12. The definition of the mean solar second

A gives us a very precise time unit for the most exacting scientific work.

B is in common use by scientists all over the world.

C is now being replaced by a time unit based on the vibrations of subatomic particles.

D has a different length in different parts of the world.

E. None of these is correct.

(Please return to page 68 of the Study Guide to continue with the lesson)

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Articulated Multimedia Physics

Lesson 1 Tape Segment 4

WORKSHEET

13. A stone on the surface of the moon

A has no weight.
B has a small weight but no mass.
C has a small mass and a large weight.
D has the same mass but a different weight than on earth.
E none of the above is correct.

14. On the moon, a 120 lb boy would weigh about

A 120 lb.
B 20 lb.
C 60 lb.
D 140 lb.
E none of the above is correct.

15. Which one of the following statements about mass and weight is true?

A Mass and weight are exactly the same things.
B Weight is defined as the quantity of matter in a body.
C Mass is defined as the pull of gravity on matter.
D The weight of a body is always one-sixth of its mass.
E None of the above is true.

(Please return to page 26 of the Study Guide to continue with the lesson)

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Articulated Multimedia Physics

Lesson 1 Tape Segment 5

WORKSHEET

16. Select the true statement:

A Parallax can never be eliminated.

B Parallax can be minimized by using proper precautions.

C Parallax occurs only when the two objects being sighted are parallel to each other.

D Parallax cannot account for instrument-reading errors.

E None of the above is true.

17. A student holds two pencils upright in positions such that one hides the other when his eye is placed in a given position. If he moves his head a few inches to the right, then

A the pencil nearer him will appear to the right of the other.

B the pencil nearer him will appear directly in front of the other.

C the pencil nearer him will appear to the left of the other.

D the rear pencil will still not be visible.

E none of the above correctly describes what he will see.

18. In using a metal tape, a carpenter lays the tape flat on the object being measured. His parallactic error will be quite small, if any, because

A the tape is very thin.
B he doesn't need accurate measurements.
C the tape graduations are very precise.
D the tape divisions are accurately spaced.
E none of the above is the correct explanation.

(Please return to page 59 of the Study Guide to continue with the lesson)

PLEASE REWIND THE AUDIO TAPE
BEFORE PROCEEDING

PROBLEM ASSIGNMENT

Articulated Multimedia Physics

LESSON 1

Instructions: (1) All problems are to be fully solved on standard size 8-1/2" x 11 " paper, ready to be submitted to your instructor when completed.

(2) Draw a rectangular box around each answer and the accompanying unit to make the answer stand out.

(3) Be sure each sheet you submit carries your full name, your class designation, and your identification number.

1. Convert 4.25 km to m. (Always include unit with answer).

2. Convert 186,000 mi to km. (Don't forget final unit).

3. A box is 3 cm wide, 4 cm long, and 2 cm high. Find (a) the area of its base and (b) its volume. (Don't forget to include unit).

4. When 10 similar coins are dropped into a graduated cylinder, the level of the water in the cylinder rises from 51 ml to 75 ml. (A ml is a milliliter, or 1 cubic centimeter). What is the average volume of each coin? (Don't forget units. No more reminders).

5. How many cm^2 are there in 1 in^2?

6. A circle having a diameter of 10 cm is cut out of a square sheet of paper 10 cm on a side. What is the area of the part of the sheet that is left over?

7. A cubical box 1 ft on an edge is filled with water to a height of 6 in. When a piece of iron is completely immersed in the water, the level rises to 8 in. What is the volume of the iron?

8. A coin has a radius of 1.0 cm and a thickness of 1.5 mm. What is the volume of the coin?

9. A ball bearing has a radius of 8 mm. A second bearing has a radius of 2 mm. If they are made of the same kind of steel, what must be the ratio of the volume of the larger bearing to the volume of the smaller bearing?